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MONITORING OF LARGE INSTABLE AREAS: system reliability and new tools.

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The monitoring of unstable or potentially unstable areas is a necessary operation every time you can not remove the conditions of risk and apply to mitigation measures. In Italian Apennine regions there are many urban or extra-urban areas affected by instability, for which it is impracticable to remove hazard conditions, because of size and cost problems.
The technological evolution exportable to the field of land instability monitoring is particularly lively and allows the use of warning systems unthinkable just few years ago. However, the monitoring of unstable or potentially unstable areas requires a very great knowledge of the specific problems, without which the reliability of the system may be dangerously overestimated.
The movement may arise, indeed, in areas not covered by instrumentation, or covered with vegetation that prevents the acquisition of both reflected signals in the multi-beam laser techniques and radar signals. Environmental conditions (wind, concentrated sources of light, temperature changes, presence of animals) may also invalidate the accuracy of the measures, by introducing modulations or disturbance at a level well above the threshold of alarm signal, leading consequently to raise the values of the warning threshold.
The Authors have gained long experience with the observation and monitoring of some large landslides in the Southern Apennine (Aliano, Buoninventre, Calciano, Carlantino, etc.) and unstable areas also at regional scale. One of the most important experiences is about the case of landslides of extensive areas, where unstable and stables zones coexist along transverse and longitudinal axis. In many of these cases you need the accurate control of the movement at selected points to evaluate the trend of displacement velocity, which can be achieved by means of a single-beam laser. The control of these movements, however, does not provide information on stress pattern into the stable areas.
Among the sensitive precursors, acoustic emission (AE) measurement has constituted for decades a monitoring system able to define precisely, in presence of a favourable geometry, the micro-cracks pattern, describing both propagation of cracks and formation of failure surfaces.
In stiff materials the deformations are associated to micro distortions or micro failures, with release of vibrational energy in the acoustic range of the frequencies. Therefore, the survey of such precursors can result extremely profitable to the goals of an early recognition of the evolution of stress states towards the failure.
For this reason, the survey of AE in geological materials, besides monitoring and forecast of landslide movements, has revealed very useful in other fields, as the safety auscultation of the mines, the stability of underground deposits of liquid and gaseous hydrocarbons and radioactive cinders, and the forecast of avalanches.
The studies in literature, especially in the mining field, have underlined that the typical emission is in the low frequencies range, where waves suffer a limited attenuation in the propagation through the rocks. The generation of micro-fractures is, on the other hand, accompanied by acoustic emission at higher frequencies.
The Authors in the last years have experienced the possibility of acoustic emission measurement, finally coming to the design and construction of a simple mono-channel device. This device is unable to determine the location of the spreading point of new failures, which is possible only with more than three channels devices. A mono-channel device can realize:
a - recognition of the phenomenon (definition of AE frequency range of rock mass under examination, characteristic ampleness),
b - recognition of the physiological activity (number of issues in time),
c – enucleation of the remarkable noises from those physiological or occasional produced outside.

The third point is realized through the transformation of sampled noise in FFT, for which is easier to define a threshold, after an appropriate period of learning, which allows to configure the system as an expert system.
The selection of in situ signals allows the use of very short transmission reports, simply consisting in outside threshold events into the time range, usually chosen as 1 hour.
The monitoring of AE is currently in progress in numerous landslide sites in Southern Italy. The longest recording is performed in the Aliano landslide site, were still today part of the landslide body translates at the velocity of 0.5 mm per day.
In the Aliano site, part of the recordings has been contextual to a notable mobilization of the landslide, so that has been possible to compare the released acoustic emission with the recordings of the surface movements. Data analysis revealed that the first significant acoustic activity preceded mass movements of almost 24 hours.
The good performance confirm the potentiality of the AE monitoring to retrieve early elements discriminated by the wave type, form and intensity, which can be well correlated to the beginning of the rupture of an unstable soil mass, time before the same moves.
The technique of measurement is not affected by typical problems of optical measures, it is not subjected to reflection of surface EM signal and can be integrated into the new generation monitoring systems.